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What is the difference between "standard deviation" and "standard error of the mean"? Which should I show in tables and graphs? FAQ# 201

It is easy to be confused about the difference between the standard deviation (SD) and the standard error of the mean (SEM). Here are the key differences:

- The SD quantifies scatter — how much the values vary from one another.
- The SEM quantifies how accurately you know the true mean of the population.
- The SEM, by definition, is always smaller than the SD.
- The SEM gets smaller as your samples get larger. This makes sense, because the mean of a large sample is likely to be closer to the true population mean than is the mean of a small sample. With a huge sample, you'll know the value of the mean with a lot of precision even if the data vary a lot.
- The SD does not change predictably as you acquire more data. The SD quantifies the scatter of the data, and increasing the size of the sample does not change the scatter. The SD might go up, or it might go down; you can't predict. On average, the SD will stay the same as sample size gets larger.

So which should you show?

If your goal is to present your data clearly, follow these rules:

- If you want to show the variation in your data, as you should if the variation is biological, then the best thing to do is show every individual value on a scatter plot. If you must show the scatter as an error bar, rather than individual values, then show the SD.
- If you want to show how precisely you have determined the mean, then plot the 95% confidence interval. An alternative is to show the SEM. When all the scatter is due to experimental imprecision (rather than biological variation), your goal is often to show the precision of the mean rather than the extent of the scatter.
- Always state whether your error bars are SD or SEM (or something else) in figure legends.

If your goals are different, here is an unique approach, advocated (as a joke) by Steve Simon in his excellent [weblog](#):

- When you are trying to emphasize small and unimportant differences in your data, show your error bars as the standard errors for the groups and hope that your readers think they are standard deviations.

- When you are trying to cover-up large differences, show the error bars as the standard deviations for the groups, and hope that your readers think they are a standard errors.

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